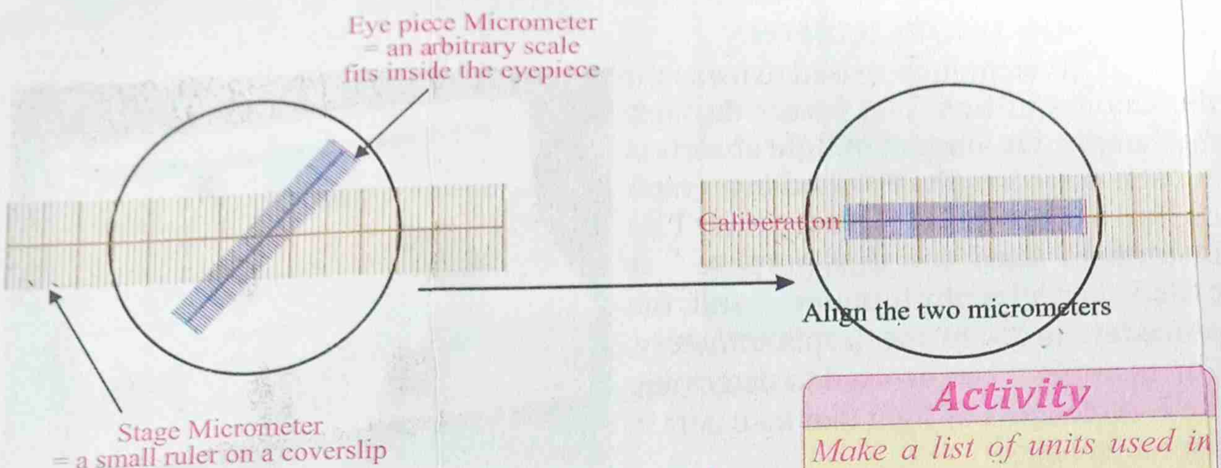


Fig. 1.6 Graticule

Activity

Make a list of units used in micrometery.

The stage micrometer is a glass slide on which a series of vertical lines are present (100 divisions). Its total length is 1mm.

1mm = 100 divisions

100 divisions = 1000 micrometers

1 division = 0.01mm (10µm)

Do you know?

A micron is an abbreviated term for micrometer. This is about 0.00004 inches or 1/1,000,000 meter.

1.2 Cell wall and plasma membrane

Structure of Cell

The cell consists of following parts.

Tit bits

The plasma membrane is outer living membrane of all the cells. Many cells have rigid or semi rigid dead covering outside the cell membrane called cell wall.

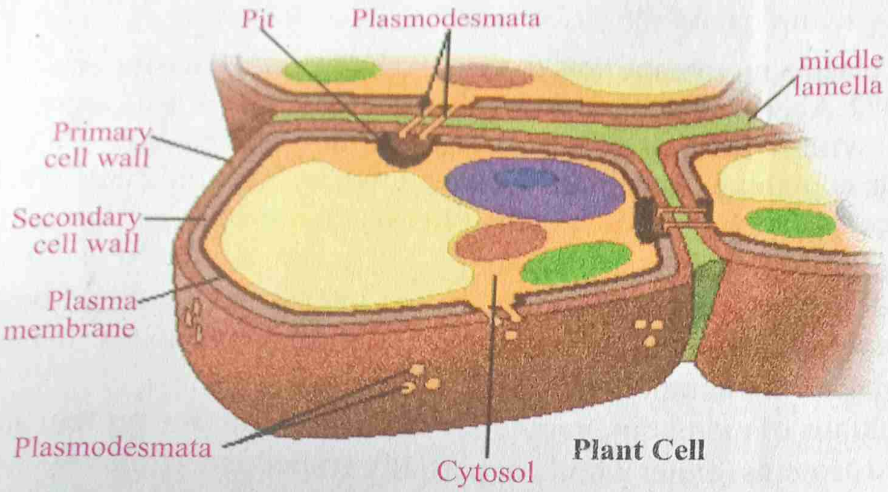
1.2.1 Cell wall

Cell wall is the outer most nonliving covering present in Plants, Algae, Fungi and Prokaryotes. It is secreted by the protoplasm of the cell. Its thickness and composition varies in different groups of organisms. Here we will discuss the detail of plants cell wall.

Structure and composition of cell wall

The plant cell wall consists of three layers i.e primary cell wall, middle lamella and secondary cell wall.

Primary cell wall is a true wall formed in developing cells. Some plant cells possess only primary cell wall such as leaves, storage cells and young growing cells. Primary cell wall is composed of **cellulose, hemicellulose** and **pectin**. The outer part of primary cell wall of plant epidermis is usually impregnated with cutin and wax, forming a permeability barrier known as plant cuticle. The cellulose microfibrils are arranged in criss cross manner. The microfibrils are held together by hydrogen bond to provide high **tensile strength.**



Plant Cell

Cellulose Fibrils

Fig. 1.7 Plant Cell Walls

Middle lamella

It is the first layer that is deposited at the time of cell division between two adjacent cells. It is formed of sticky gel like magnesium and calcium salts of proteins which help to stick the neighbouring cells together.

Secondary cell wall is thick layer formed between the primary cell wall and plasma membrane. The secondary cell wall is formed when the cell is fully grown. It is composed of cellulose, hemicellulose and lignin which is used to strengthen the wall. In the secondary cell wall the microfibrils also show criss cross arrangement. Cells with secondary cell walls are rigid.

1.2.2 Plasma Membrane

It is outer most living boundary of animal cells while in plant cell, it is always present after the cell wall. There are many other membranes bounded organelles, like mitochondria, Golgi bodies, Endoplasmic reticulum. All these membranes are chemically composed of 60- 80% proteins, 20 to 40% lipids and small amount of carbohydrates.

Tit bits

Cellulose, the main constituent of cell wall, is used in the manufacturing of paper, cotton goods, sellotape, ropes etc.

Do you know?

Cell wall provides mechanical strength shape, support and protection to cell.

Do you know?

Plant cells are communicated with each other by microscopic channels known as

Tit bits

The plasma membrane consists of 3 classes of amphipathic lipids, phospholipids, glycolipids and sterols. The amount of each depend on the type of cell. Usually phospholipid is most abundant.

Fluid mosaic model:

This model of plasma membrane was developed by **Jonathan Singer** and **Garth Nicolson** in 1972. According to this model plasma membrane is fluid mosaic of protein, floating within bilayer of phospholipid and cholesterol. The phospholipid molecule contains a hydrophilic head and two hydrophobic tails. The hydrophobic tails face each other while hydrophilic heads are directed towards water which is present outside and inside the cell.

The cholesterol molecules are embedded in the interior of the membrane which makes the membrane less permeable for water soluble substances. It also provides stability to plasma membrane.

There are two kinds of membrane proteins, **extrinsic** or surface protein and **intrinsic** or embedded proteins (either wholly or partially embedded in bilayer).

Some amount of carbohydrates are also present in plasma membrane. These may either attach with protein as glycoproteins or attached with lipids as glycolipids.

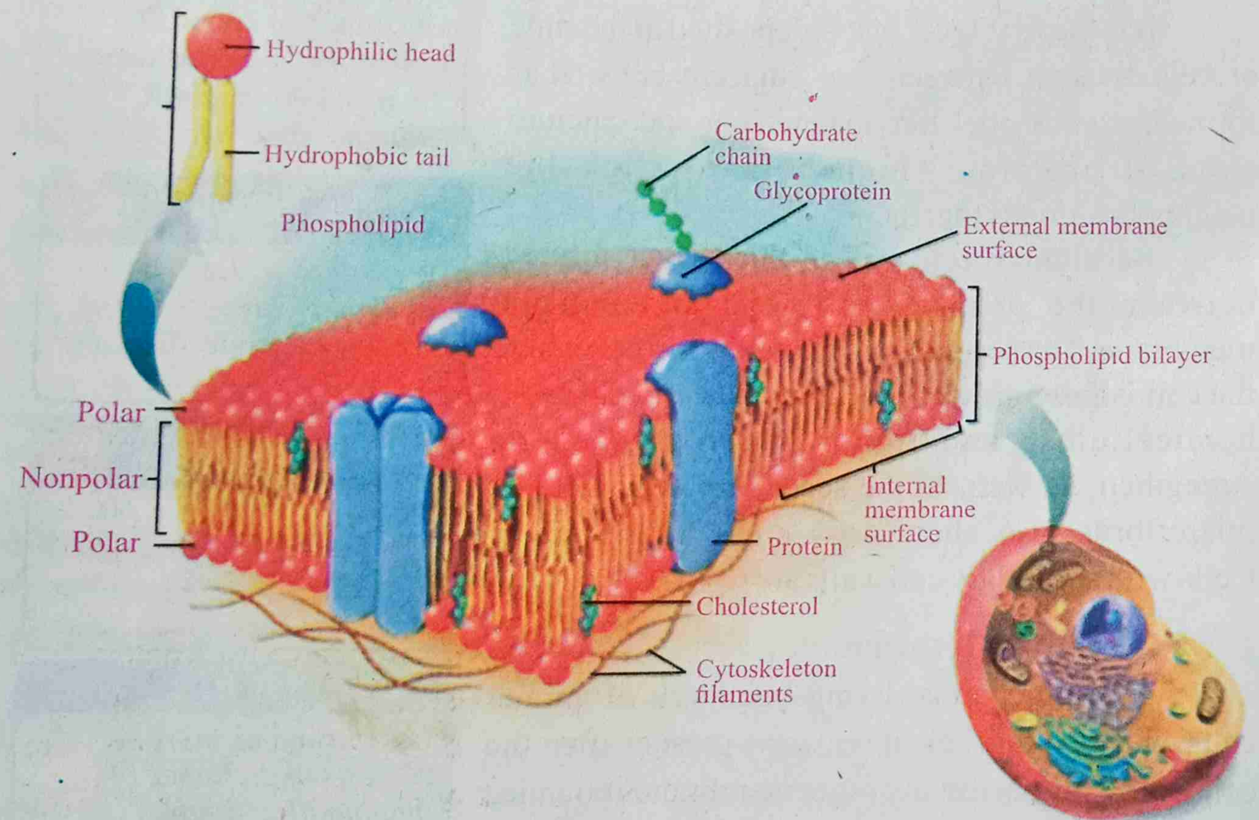


Fig. 1.8 Fluid Mosaic Model of Plasma Membrane

The role of glycoproteins and glycolipids:

They provide receptor sites for hormones, nerve impulses, recognition of antigens and also responsible for endocytosis. Therefore, these are called as cell

surface markers. Cell to cell recognition, sticking, correct cell together. They are just like signboard on a shop.

Protein of plasma membranes:

Channel proteins and carrier proteins:

These are involved in the passage of molecules through the membranes. Some proteins have channels through which substances can move across the membrane while other molecules combine with carrier proteins to move across the membrane.

Enzymes:

Some proteins of plasma membrane act like enzymes, e.g., the epithelial cells lining, some parts of the digestive tract contains digestive enzymes on their cell surface membrane.

Receptor molecules:

Some proteins of plasma membrane act as receptors e.g., hormones are chemical messengers, circulating in the blood but only bind to specific target cells which have the correct receptor site.

Antigens:

Antigens are glycoproteins have different shapes, so each cell can have its own specific marker. e.g., foreign antigens can be recognized to defend the cell.

1.2.3 Role of plasma membrane with its environment

It regulates materials moving into and out of the cell. It secretes useful substances such as enzymes, hormones etc. It removes waste and toxic substances such as ammonia, urea, uric acid. It keeps a constant favorable ionic concentration within the cell for enzymatic activities and for nervous and muscular activities. The transport of substances across the plasma membrane takes place by endocytosis, exocytosis, osmosis, diffusion etc.

1.3 Cytoplasm and Organelles

The living contents of the eukaryotic cells are divided into nucleus and cytoplasm, these two together known as protoplasm. The word "cytoplasm" literally means "living gel of cell". It is liquid substance lying inside cell membrane and outside nucleus. The cytoplasm is a mixture of organic and inorganic materials and form a solution having all fundamental molecules of life i.e., amino acids, sugars, fatty acids, nucleotides, vitamins, salts and dissolved gases.

The soluble part of the cytoplasm is called **cytosol** which is about 90% water, the small molecules and ions form true solution and large molecules form **colloidal**

solution (Such as starch particles in plant cells and glycogen granules of animal cells). The colloidal solution may be in the form of a sol (non viscous) or gel (viscous) parts.

Cytoplasmic Organelles:

These are highly organized cellular bodies which perform specific functions. Such as endoplasmic reticulum, ribosome, Golgi bodies Mictochondria, plastid, centrioles, lysosomes etc.

Functions: Store House:

The cytoplasm serves as store house of vital materials, chemicals e.g., glycogen in liver cells.

Site for metabolic activities:

It is the site of certain metabolic pathways e.g., glycolysis.

Maintain the cell shape:

The cytoskeleton present in the cytoplasm, not only maintains the shape of the cell but also helps in the movement of organelles.

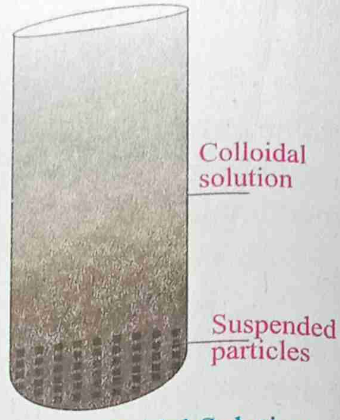


Fig. 1.9 Colloidal Solution

Tit bits

Colloidal solution is a type of solution which contain tiny particles of a substance suspended in it.

1.3.1 Endoplasmic Reticulum (E R)

Endoplasmic reticulum is a network of channels or tubules in contact and extending between nuclear membrane and cell membrane of all eukaryotic cells. The components of endoplasmic reticulum are:

Cisternae: These are long flattened and unbranched units arranged in stack

Vesicles: These are oval membrane bounded structures.

Tubules: These are irregular often branched tubes bounded by membrane. Tubules may be free or connected with cisternae.

Endoplasmic reticulum divides the intracellular space into two distinct compartments, i.e., luminal (inside) and extra luminal (cytoplasm).

Types: There are two types of endoplasmic reticulum, Rough ER and Smooth ER.

Modification of Endoplasmic Reticulum:

In skeletal and cardiac muscle cells SER is known as sarcoplasmic reticulum (SR). These store calcium ions in their lumen. If many ribosomes are attached on the small parallel cisternae of RER, then it is called **ergastoplasm.** In nerve cells the **ergastoplasm** is known as **Nissl's body.**

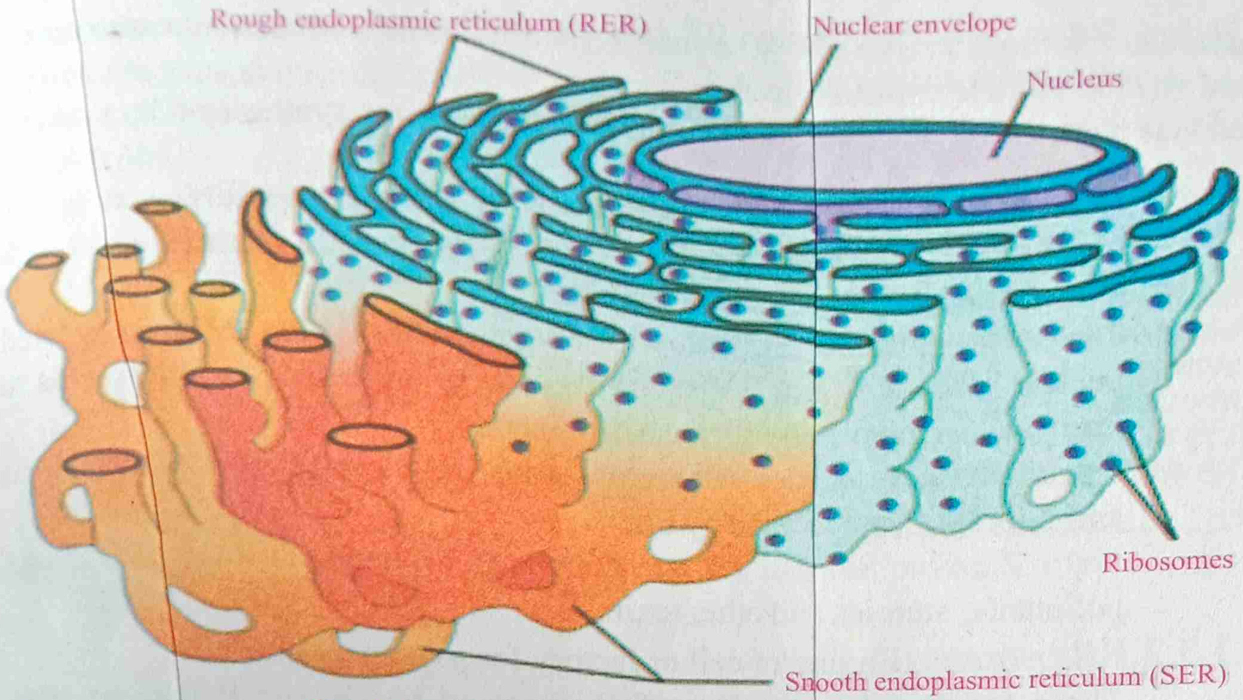


Fig. 1.10 Rugh Endoplasmic Reticulum (RER) and Smooth Endoplasmic Reticulum(SER)

Table 1.1 Differences between smooth andrough ER

Rough ER	Smooth ER
• *Ribosomes are attached with their outer surface.*	• *Ribosomes are not attached with their outer surface.*
• *More stable structure*	• *Less stable structure.*
• *Mainly composed of cisternae and vesicles*	• *Mainly composed of tubules*
• *Abundantly occur in cells which are actively engaged in protein synthesis and secretion, such as in liver, pancreas and goblet cells.*	• *Abundanly occur in the cells concerned with glycogen and lipid metabolism, such as in adipose tissues, muscles, liver cells, and also remove toxins*

Functions of ER:

i) Mechanical Support: Along with microfilaments and microtubules, ER gives mechanical support to the cell.

ii) Intracellular Exchange: The ER forms intracelular connecting system and transports material of the cell from one part to another part of the cell.

iii) Connection: The ER also helps in connecting nuclear material with plasma membrane.

iv) Protein synthesis: Rough ER helps in protein synthesis as ribosomes are attached with their outer surface.

v) Lipid Synthesis: Cholesterol and phospholipid are synthesized by smooth ER.

vi) Cellular Metabolism: The membranes of ER increase surface area for metabolic activities also contains some enzymes like, sucrases, glucose 6 phosphatase, NAD diphosphatase etc.

vii) Formation of Nuclear membrane: Fragmented elements of disintegrated nuclear membrane and E.R elements arrange around the chromosomes to form nuclear membrane during cell division.

viii) Formation of Organelles: All membranous organelles except mitochondria and chloroplast are formed by ER.

ix) Detoxification: Smooth ER are concerned with detoxification of drugs, pollutants, steroids and other toxins.

1.3.2 Ribosomes (Engine of cell or factory for protein synthesis)

These are granular structures first observed by George Palade in 1953. Ribosomes are **non membranous organelle**, present both in prokaryotic as well as eukaryotic cells (except mammalian RBCs). It is one of smallest cell organelle and also called organelle with in an organelle.

Composition: They are also known as ribonucleoprotein particle of the cell because composed of proteins and rRNAs. In prokaryotic ribosomes the amount of rRNA is 60% while protein is 40%. In eukaryotic ribosomes, protein is 60% and rRNA is 40%.

Location: The ribosomes exist in two forms, either freely scattered in cytoplasm or attached to outer surface of RER and nuclear membrane. It is also present in mitochondria and chloroplast.

Number: Numerous in number, about half a million ribosomes in a common eukaryotic cell.

Site of Synthesis: The subunits of ribosomes are synthesized in nucleolus of nucleus then transported to cytoplasm via nuclear pores. Thus nucleolus is the factory of ribosomes while ribosomes are the factory of proteins.

Subunits of Ribosomes A complete eukaryotic ribosome consists of two subunits, based on their sedimentation (S) rate. ''S'' stands for Svedberg unit. A larger sub unit of 60s and smaller sub unit of 40s. Both units collectively make 80s particle. These

Do you know?

Svedberg unit is a unit of time equal to 10^{-13} seconds used in expressing sedimentation coefficients

subunits are attached with each other by means of Mg ions or forming salt bonds between phosphate group of rRNA and amino group of amino acids or both by Mg ions and salt bonds. In prokaryote ribosome is 70s, larger unit is 50s while smaller unit is 30s.

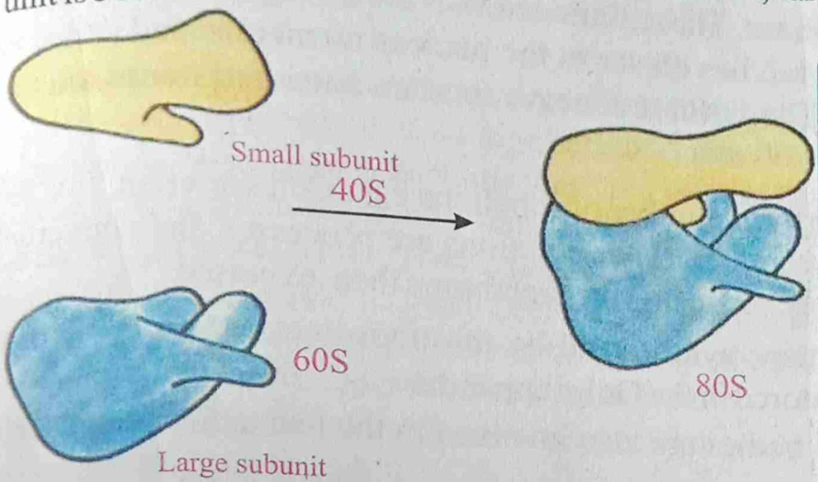


Fig. 1.11 Ribosome

> **Tit bits**
>
> *Mitochondrial ribosomes of eukaryotic cell are produced from mitochorndrial genes and functionally resemble many features of bacteria reflecting the likely evolutionary origin of mitochondria.*

Polysome

When many ribosmes attached to one mRNA strip, it is called polysome or polyribosomes. This happens during protein synthesis.

Function: Ribosomes are involved in protein synthesis which is facilitated with the help of three types of RNA and under the instructions of DNA.

> **Tit bits**
>
> *Golgi apparatus is a major collection and dispatch station of protein products, received from endoplasmic reticulum and known as post office of cell.*

1.3.3 Golgi Complex

They were discovered by Camillo Golgi in 1898, so called as Golgi complex or Golgi apparatus. In plants they are known as dictyosome.

Structure: The term Golgi apparatus refers to a set of smooth membranes that are stack into flattened, fluid filled sacs or cisternae, containing proteins, carbohydrates, glycoproteins and specific enzymes.

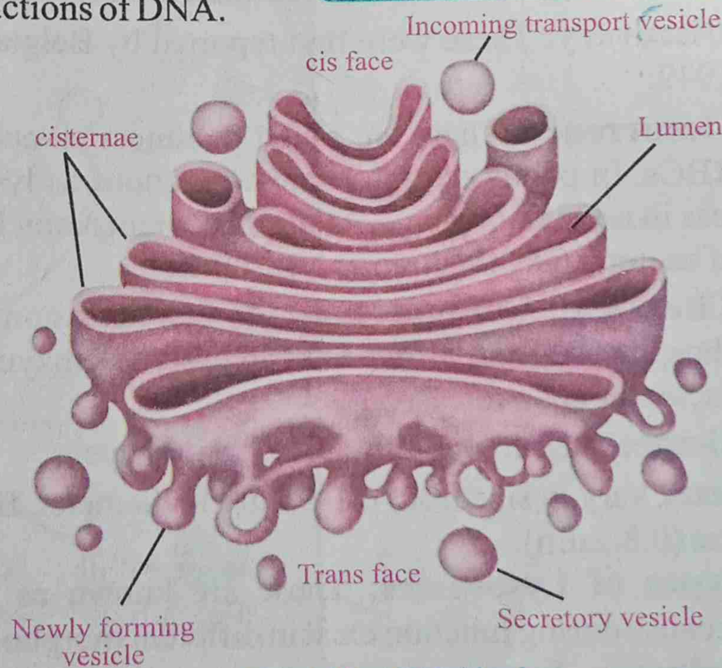


Fig. 1.12 Golgi body

Most of the Golgi apparatus is formed of flattened sacs or cisternae but some tubules and vesicles may also participate in the formation of Golgi complex. The number of cisternae ranges between 3-7 in most of animals but in lower organisms may have up to 30 flattened sacs. These flattened sacs are arranged in a concentric fashion, the convex face or sac lies closer to the nuclear membrane and called as Cis-Golgi or forming face. The farthest concave sacs are named as trans Golgi or maturing face.

Function: Golgi bodies perform number of functions e.g., Cell secretion: It is the main function of the Golgi complex. The secretions are processed and converted into finish products and are packed inside the membrane then exported.

Storage of proteins: Proteins synthesized by the ribosomes are passed to the endoplasmic reticulum and stored in the Golgi apparatus.

Cell wall formation: Golgi bodies are also involved in the formation of new cell wall by the plants.

Formation of Lysosomes: An important function of Golgi apparatus is the formation of primary lysosomes.

Formation of acrosome during spermiogenesis

Formation of vitelline membrane of egg is also secreted by Golgi bodies.

1.3.4_Lysosomes

Lysosomes (Gk. lyso: splitting, soma: body) are sac-like single membrane bounded organelles which break macromolecule in the cells.

Discovery: These were first reported by Belgian biologist Christian De Duve in 1949.

Occurrence: These are found in almost all eukaryotic cells except mammalian RBCs. In plants central vacuole functions as lysosome, therefore, lysosomes are less in number in plants. All fungi contain many lysosomes. The periplasmic space of bacteria may function as lysosome.

Chemical Composition: Lysosomes contain many enzymes like acid phosphatases and all types of hydrolytic emzymes, like carbohydrases, lipases, nucleases and proteases.

Shape: They are roughly spherical in shape.

Size: Vary in size from 0.1-0.8μm in diameter. In phagocytic WBC it is largest in size (0.8-2μm).

Types of Lysosomes: These are known as polymorphic cellular organelles because during function exist in different morphological and physiological states.

Primary Lysosome: Enzymes are synthesized by ribosomes of rough

endoplasmic reticulum and then taken to Golgi bodies where these are processed and budded off as Golgi vesicles, called primary lysosomes.

Secondary Lysosome: They are also called digestive vacuoles. They are formed by the fusion of primary lysosome with food vacuole known as phagosome (phagocytic food vacuole).

Residual Bodies or Tertiary Lysosome: Lysosome containing undigested materials after the absorption of digested food into the cytoplasm is called residual lysosome. In unicellular organisms these are removed outside of cell by exocytosis while in multicellular organisms these are retained in the cell as lipofuscin granules.

Autophagic lysosomes: Also called autophagosomes or cytolysosomes. When primary lysosome fused with dead cellular organelles such as mitochondrion which die after ten days to be digested are called autophagosomes, such as human liver cells recycle half of its macro molecules each week.

Functions of Lysosomes: Lysosomes perform many functions inside and outside of cells. Which are as under:

Intracellular digestion: Foreign substances received by the cells either by phagocytosis (solid molecules) or pinocytosis (liquid molecules) are digested by lysosome. This process is called heterophagy. The old or dead cell organelles are digested by lysosomes and stored food is also digested during starvation. This process is known as autophagy.

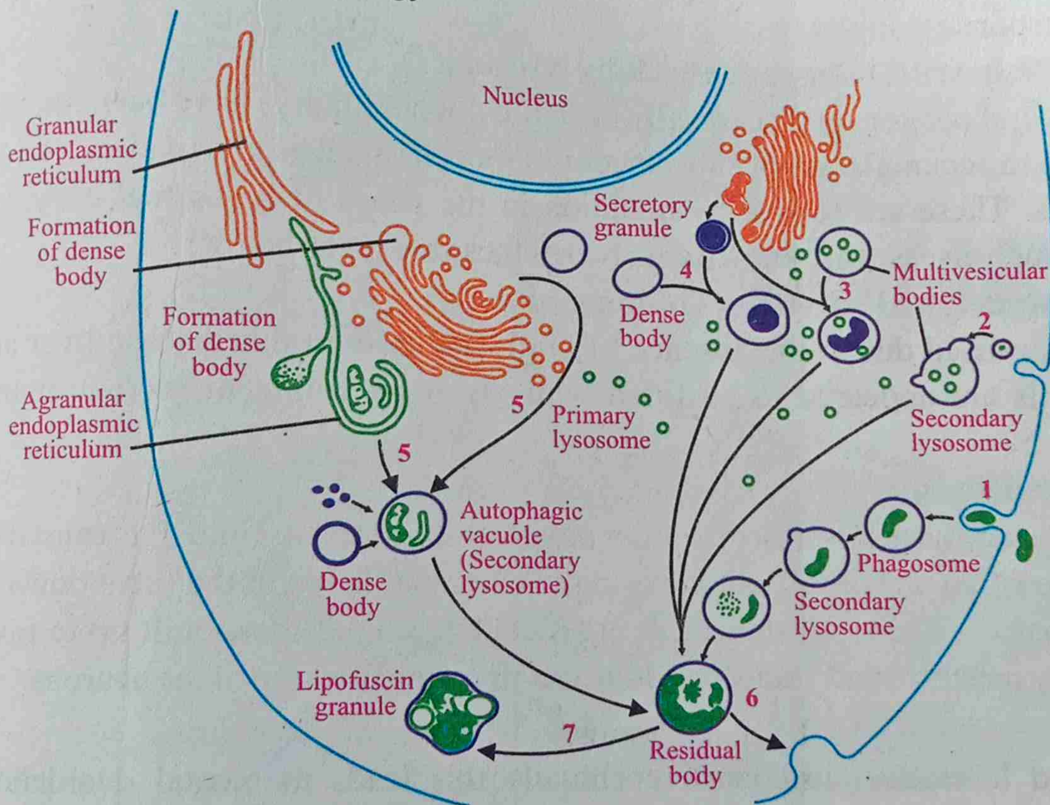


Fig. 1.13 Explained Function of Lysosome

Extra cellular digestion:

Lysosomes also help in extra cellular digestion by releasing enzymes. e.g., the lysosomes of osteoclast (Bone eating cells) dissolve unwanted parts of bone. Extracellular digestion also take place in fungi.

Autolysis:

Some time all lysosomes of cell burst to dissolve the cell completely. Thus also called suicidal bags because old cells like WBCs, platelets and epithelial cells are removed by autolysis. It also destroys unwanted organs of embryo such as tail of human embryo and tail of tadpole.

Crinophagy:

The excess hormones of endocrine gland may be digested by lysosome. This process is known as crinophagy.

Exocytosis or cell excretion:

Sometimes enzymes of primary lysosomes are released from the cell. This occurs during replacement of cartilage by bone during development. Similarly the matrix of bone may be broken down during remodeling of bone that can occur in response to injury.

Tit bits

Glycogen-storage disease (GSD) may be treated by taking small meals of carbohydrate, in USA one child per 25000, births have GSD.

Storage Diseases (Diseases due to faulty lysosomes)

Several congenital diseases (by birth but not hereditary) have been found to occur due to accumulation of substances within cell. Such as glycogen or various glycolipids. These are caused by mutation in the genes of lysosomal enzymes. About 20 such diseases are known e.g., two of these are given below:

Glycogenesis type II disease (G-Storage disease)

It is caused due to the absence of D-glycosidase. In this disease liver and muscle cells are appeared to be filled with glycogen within membrane bound organelle.

Tay-Sachs disease:

Tay-sach disease is a rare disorder passed from parent to child. It is caused by the absence of an enzyme (Beta hexosaminidase) that helps in the breakdown of fatty substances. These substances in brain called gangliosides, built up to toxic level mainly in babies and young children and affect the function of the neurons.

Symptoms

Child loses muscle control eventually this leads to mental retardation, blindness, paralysis and even death.

1.3.5 Mitochondria (Gk. mitos : thread, chondrion: granules)

Mitochondria (Singular mitochondrion, **Power house of the cell**) look like small thread or granule either spherical or elongated. It is self replicating organelle.

Altman (1890) established them as cell organelle and called them bioblast. The term mitochondria was given by C. Benda (1898).

Size:- The diameter of mitochondria is 0.2-1 µm while length is one µm to 4.1 µm. Their numbers are few to many thousand per cell, depending upon physiological activity of the cell.

Chondriome:- All the mitochondria present in a cell are collectively called chondriome. Usually animal cell have more mitochondria than plants.

Structure:- It is double membrane structure. The outer membrane is smooth while the inner membrane is folded. If outer membrane of mitochondria is removed then it is called as **mitoplast.** The folds of inner membrane are known as **cristae** which increase surface area for chemical reactions. These cristae contain (bear) pin head particles called **oxysomes** or elementary particles or F1 particles. Inside the inner membrane a fluid is present called matrix. The matrix contains enzymes for cellular aerobic respiration, proteins, 70s ribosomes, RNA and double stranded circular DNA. (It is 1% of total DNA of cell.) This DNA can code the synthesis of some type of proteins.

Tit bits

mitochondria is also called

- *Power house of the cell or ATP mill in cell.*
- *Cell within cell.*
- *Cell furnace or storage batteries.*
- *Most busy and active organelle in cell.*
- *Semi autonomous cell organelle.*

Tit bits

F1 particles or oxysomes are knob like structures located on cristae of mitochondria and they are helpful in cellular respiration. They contain ATP synthetase which is responsible for the synthesis of ATP.

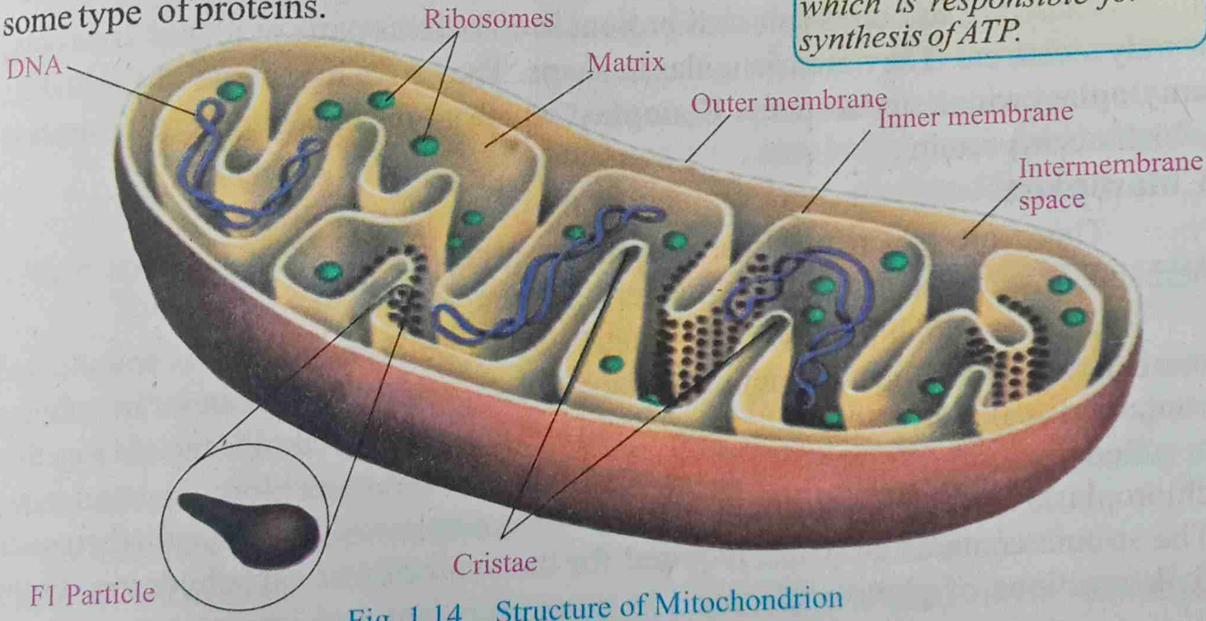


Fig. 1.14 Structure of Mitochondrion

Function of Mitochondria:

They provide site of aerobic respiration. Most of the oxidative metabolism and ATP production occurs in mitochondria. Therefore mitochondria are called power houses of the cell.

$$C_6H_{12}O_6 + 6O_2 + Pi + ADP \longrightarrow 6CO_2 + 6H_2O + ATP$$

Mitochondria also help in vitellogenesis (Yolk formation) in oocyte.

Tit bits

It is believed that mitochondria have endosymbiotic origin from purple sulphur bacteria or prokaryotic cell. The ribosome of mitochondria and DNA are similar to prokaryotic cell.

1.3.6 Plastids

The plastid (Gk. Plastos: formed, molded) is a major double membrane organelle found in plant cells. Plastids are the sites of manufacture and storage of important chemical compounds used by the cell. They often contain pigments used in photosynthesis and many types of pigments that can change or determine the cell colour for different purposes. Plastids are classified into chloroplasts, chromoplasts and leucoplasts. All types of plastids are formed from a precursor molecule proplastids.

Chromoplasts:

These are pigmented plastids located in colourful (other than green) parts of plants like petals fruit covering. These plastids also help in cross pollination. These also contain chlorophyll but in very less amount.

Tit bits

Most plants inherit plastids from one parent e.g., angiosperms inherit plastid from female gamete while many gymnosperms inherit plastid from male pollen.

Leucoplasts:

These are colourless plastids present in colourless parts of plants like roots, woody stems etc. They are triangular in shape. They help in storage of food. e.g., **amyloplast** which stores starch, **Elaioplast** which stores lipids and **proteinoplast** which stores protein.

Chloroplast:

These are green plastids, present in green parts of plants like leaves, herbaceous stems, unripened fruits coverings etc.

They are double membrane structures. The outer membrane is smooth and more permeable while the inner membrane is less permeable. The inner membrane contains disc like structure called thylakoid and group of thylakoid stacked together is called **granum** (plural Grana). There are many grana in a chloroplast and many chloroplasts in a cell (up to 40). The fluid which surrounds grana is called **stroma.** The stroma contains enzymes required for the synthesis of carbohydrates during dark reactions of photosynthesis. The most abundant and important enzyme is

Rubisco (about 16% of chloroplast), stroma also contains small amount of DNA, RNA and 70s ribosome. Presence of these substances indicate that it is **semiautonomous** organelle of cell like mitochondria.

The grana are connected to each other by long thylakoid membrane called **lamellae.** The chloroplast is the site for photosynthesis. The light reaction takes place in grana which contains large number of photosynthetic pigment in an organized manner, while the dark reactions occur in stroma. It is believed that chloroplast originated from cyanobacteria through endosymbiotic process.

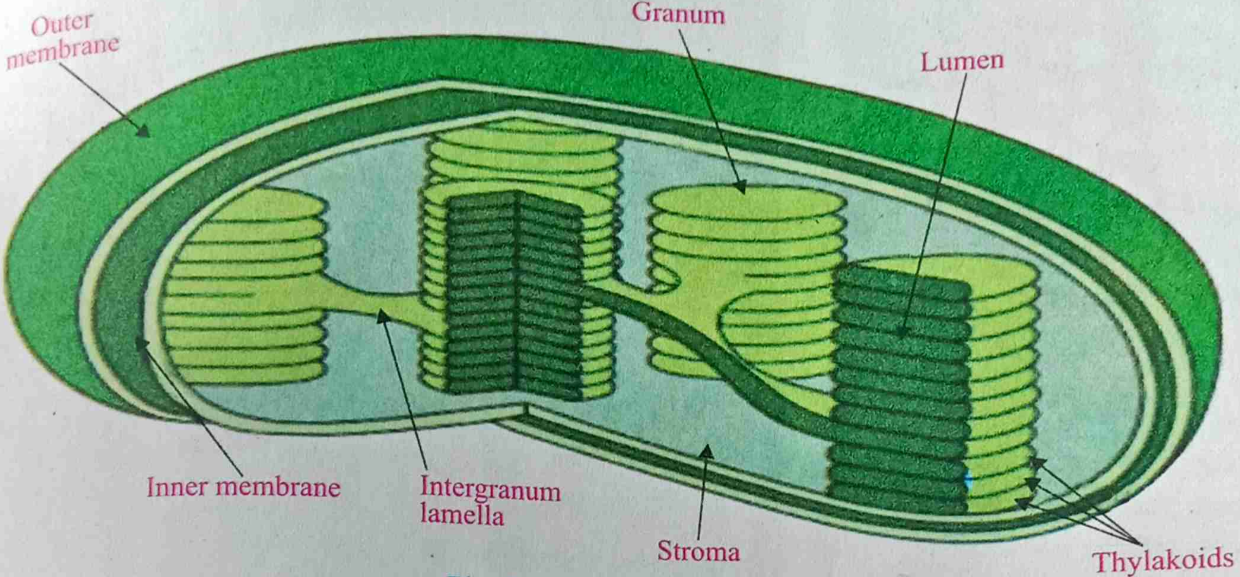


Fig. 1.15 Chloroplast

1.3.7 Cytoskeleton

The cytoskeleton (Gk: Kytos, cell ; Skeleton, dried body) are unbranched cylindrical structures which are made up of proteins and involved in internal structure, movement, contraction, relaxation, and maintain cell shape.

There are three types of cytoskeleton elements based on size and chemical composition, i.e., microtubules, microfilaments and intermediate filaments.

Microtubules:

These are small hollow cylinders, made of self assembling **tubulin protein**, 25nm in diameter. In plants microtubules often found associated with cell wall. Perhaps these are involved in the transport of cell wall materials from Golgi bodies to outside of the cell. During cell division, these microtubules form spindle fibers. Several cell organelles are also derived from special assemblage of microtubules e.g.,cilia, flagella, basal bodies and centrioles.

Microfilaments:

Microfilaments are considerably more slender, made up of contractile

protein called **actin** and linked to the inner face of the plasma membrane. These are about 7.0 nm in diameter and occur in bundles or mesh like network. Actin filament contains two chains of actin molecules twisted to each other. Besides the actin protein tropomyosin and troponin proteins also present.

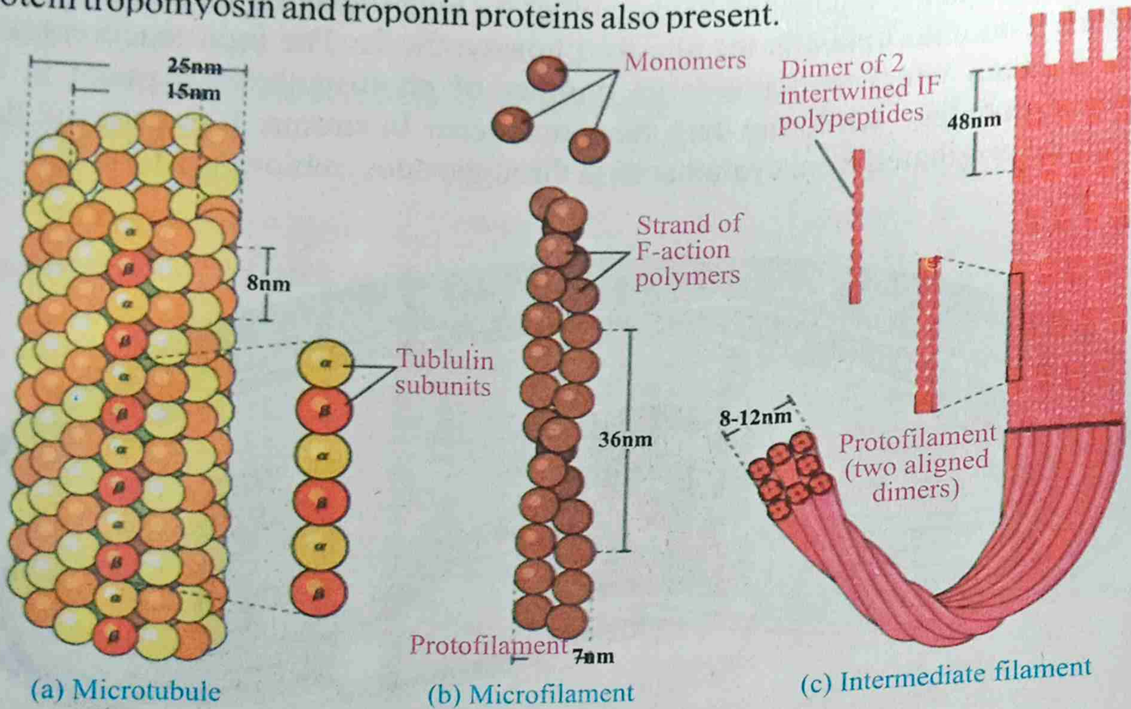


Fig. 1.16 Cytoskeleton

These perform functions of muscle contraction, change in cell shape including division of cytoplasm during cell division.

Intermediate filament:

These filaments are called intermediate because these are intermediate in size between microfilament and microtubule (about 8-12nm) in diameter. These are composed of **vimentin** protein. The intermediate filaments assemble and disassemble and, therefore, play important role in maintaining shape of cell, attachment of muscle cell, support of nerve cell processes i.e. axon.

1.3.8 Peroxisomes

It is a tiny single membrane bound cell organelle, which contain large amount of oxidative enzymes (such as peroxidase, catalase, de-amino acid oxidase, etc.).

These are spherical shaped organelle about 0.6 to 0.7μm in diameter. Their number varies between 70 to 100 per cell. It was first isolated by **De duve and co worker in 1965** in liver cells and other tissues which are rich with oxidative enzymes. It is also found in protozoans, yeasts and many higher plants.

Function

The name peroxisome was applied because this organelle is specifically involved in the formation and decomposition of hydrogen peroxide (H_2O_2) in the cell.

$$H_2O_2 \rightleftharpoons H_2O + \frac{1}{2} O_2$$

1.3.9 Glyoxisomes

These are cell organelles, mostly found in lipid rich seeds and seedling cells of plants. These contain enzymes like glycolic acid oxidase and catalase. Some other enzymes are also present which are involved in the conversion of lipids into carbohydrate by a process called glyoxylate cycle.

1.3.10 Centrioles

Centrioles are non-membranous organelles, two in number, located near the outer surface of nucleus. The diameter of centriole is 10nm. They are found in animal cells of some microorganisms and lower plants while absent in higher plants. Centrioles were **discovered by Beneden in 1883 and Boveri in 1895**.

Structure:

The cytoplasm which surrounds centrioles is called "centrosphere". Centrioles and centrosphere are collectively called centrosome. In cross section each centriole consists of a cylindrical array of nine microtubules. However, each of the nine microtubules is further composed of triplet tubules. Both centrioles are placed at right angle to each other.

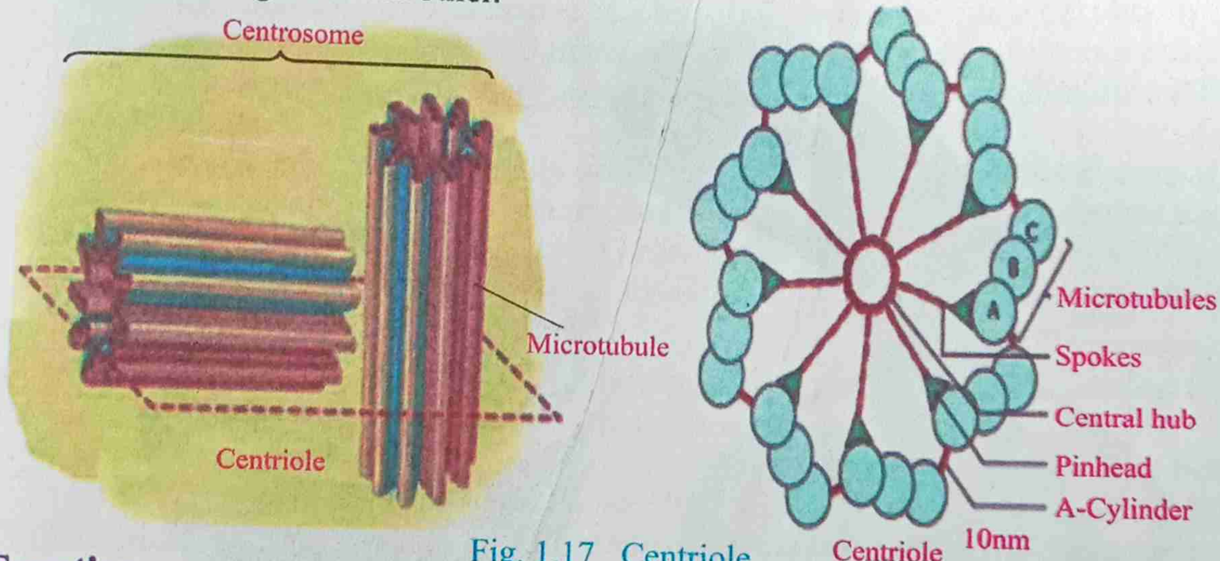


Fig. 1.17 Centriole

Function

They help in cell division. They are self replicating units and replicate just before the cell division. Each pair migrate towards opposite side of the nucleus. The spindle fibers are formed between

> **Tit bits**
>
> *Prokaryotic cells also have cytoskeleton which have same function but their structure is simple.*

these two pairs of centrioles. They play an important role in the location of furrowing during cell division and arrangement of microtubules.

1.3.11 Cilia and Flagella

Cilia (L. cilium, eye lash) and Flagella (L. flagella means whip) are hair like outgrowths of cell membrane and elongated appendages. They are present on the surface of some cells. They help in the movement of the cell. Some stationary cells also contain cilia (such as epithelial lining in respiratory system). The stationary cilia help in the movement of materials over the surface of the cell.

Flagella are five to twenty times longer than cilia. However, both cilia and flagella have same internal structure. They are membrane bounded **cylinders**. This membrane encloses a **matrix.** The matrix contains axonemes or axial filaments. The axonemes consist of nine pairs (doublets) of microtubules, which are arranged in a circle around two central tubules. This arrangement is called 9+2 pattern of microtubules. Microtubules slide over each other during movement of cilia and flagella. Each microtubules has two structures, the **dynein arms** which project towards the neighbouring doublets and

Do you know?

Basal bodies of cilia and flagella are types of centrioles.

Tit bits

Sperm centrioles are important for 2 functions. To form the sperm flagellum and sperm movement and in the development of embryo after fertilization.

Fig. 1.18 Ultra Structure of Cilia and Flagella

spokes which extend towards the centre. Dynein have ability of hydrolysis of ATP and release energy for ciliary or flagellary movements. The flagella and cilia originate from the basal body (also called Kinetosome) which is modified form of centriole. Basal body controls the growth of cilia and flagella. Microtubules in the basal body form 9 + 0 (9 triplets) pattern. Basal body exhibits cartwheel structure.

Mechanism of movement:

Movement of these structures is due to the sliding of double fibrils into groups one after the other. (suggested by **Bradford**, 1955).

Effective stroke:

During effective stroke five out of nine double fibrils contract as a result cilium bends.

Recovery stroke:

During recovery stroke four out of nine double fibrils contract and make the cilium straight.

1.3.12 Nucleus (Greek. karyon= central commander)

Nucleus is a double membrane bounded cell organelle of eukaryotic cell. It was discovered by Robert Brown in 1831 in orchid cell. Nucleus controls all cellular metabolism and contains genetic information of the cell. Nucleus is considered as **controller** or **heart** or **brain** of the cell.

It is self replicating organelle, arises from division of pre-existing nucleus. Generally each cell contains one nucleus but sometime may be two to many, **dikaryote in *Paramecium*** and many in ***Opalina***. It is absent in some eukaryotic cells, such as in mature phloem sieve tube elements in plants and mature RBCs of most mammals.

In animal cells, it generally occupies the **central space** while in case of plant cells, it is pushed towards **periphery** due to the presence of a large central vacuole. It may be spherical, oval, elongated or irregular in **shape.** It is only visible when the cell is in non dividing stage. In dividing cells it disappears and chromatin material is replaced by chromosomes.

Structure: The nucleus of non dividing cell (inter-phase) consists of nuclear membrane, nucleoplasm, chromatin net and nucleolus.

Each nucleus is covered by two **parallel membranes** with a space between (10-50 nm) called the perinuclear space. It is composed of protein and lipid bilayer, like plasma membrane. The outer nuclear membrane is at places continuous with endoplasmic reticulum while inner nuclear membrane encloses the nuclear contents. The ribosomes are also attached to outer surface of nuclear membrane.

At certain points nuclear membrane is provided by **nuclear pores,** around the margins of these nuclear pores both membranes are fused with one another. These pores are also guarded by permeases in the form of a pore complex which

regulate RNA, ionic exchange (i.e., **nucleocytoplasmic traffic**) between nucleoplasm and cytoplasm. Nuclear membrane is also known as nuclear envelope.

Nucleoplasm: Nucleoplasm is ground substance of nucleus, which is also known as nuclear matrix or karyoplasm.

Chemical composition of nucleoplasm: It is a transparent complex colloidal form of solution or fluid contains water, protein and enzymes like ATPase, DNA and RNA polymerases, endonucleases. It also contains nucleotides and mineral ions (Ca^{++}, Mg^{++}) etc.

Nucleolus: Nucleoplasm also contains one or more nucleoli, which is non-membrane bound and spherical structure so that the content of nucleus is continuous with the rest of the nucleoplasm. Nucleolus usually attached to chromatin at specific site called nuclear organizer region (NOR). It is visible only during interphase while disappear during cell division.

It contains 85% proteins, 10% RNAs and 5% DNA.

The main function of nucleolus is to form sub units of ribosomes which move to cytoplasm by nuclear pore thus known as ribosome factory of the cell.

Chromatin net is network of nucleoprotein fibres, embedded in nucleoplasm. Chromatin fibres contain genetic information and condensed to form chromosomes during cell division.

Chemically chromatin consists of largely protein both histone (basic protein) and non histone (acidic protein), DNA and little amount of RNA.

Fig. 1.19 Nucleus and Chromosome

Chromosomes (Greek - chromas : color, Soma: body)

Chromosome is highly condensed form of the chromatin, seen only during cell division. It often deeply absorbs basic dyes during staining thus darkly stained structure.

Chromosomes can be best studied at metaphase stage because size of chromosomes is the shortest during metaphase.

Karyotype

The number of chromosomes is definite for each species, for example in human, each body cell contains 46 chromosomes, Mucor (Fungs) 02, Pea 14, Maize 20, Frog 26, Chimpanzee 48, Fruit Fly 08, *Ascaris* (round worm) 02 etc. Each chromosome can be identified by its size and shape.

Structure of Chromosome

At metaphase stage, each chromosome consists of two identical (sister) cylindrical structures called chromatids. Both sister chromatids are connected together by a common centromere. Around the centromere is a disc of protein called kinetochore where spindle fibers get attached during cell division. Each chromatid is consist of a single long thread of DNA associated with histone and non-histone proteins, RNA is also present in it . Chromosomes are covered by thin proteinaceous sheath called pellicle. They are the vehicle of hereditary material (genes) from parent cell to daughter cell.

> **Do you know?**
>
> *Which human cells do not possess nucleus and which cells are multinucleated?*

1.4 Bacteria as a Model Prokaryotic Cell

Bacteria despite their simplicity, contain a well developed cell structure which is responsible for some of their unique biological structure. The cell wall is composed of **peptidoglycan** (murein) while in eukaryotes it is either composed of **cellulose or chitin.** Beneath the cell wall is cell membrane which lacks sterol such as cholesterol. Their plasma membrane contains respiratory enzymes. In many bacteria slimy capsule is present which is secreted by cell. Flagella are present in most bacteria which are chemically composed of **flagellin** protein. Many of gram -ve bacteria possess hollow proteinaceous filament known as pili. These pili are anchored in the membrane and project through the cell wall. They help in conjugation and attachment on the surface of tissues of the host. They are very thin, only visible under electron microscope and composed of **Pilin protein.** The cell membrane of some bacteria are folded into a structure called mesosome which help in respiration, photosynthesis and formation of new cross walls during cell division. The ribosomes of bacteria are small (70s) but numerous in number. Bacteria have **plasmids** which are small circular rings of DNA and contain genes for drug resistance, heavy metals and insects resistance. Some bacteria also have **transposons.** They are semi parasitic sequences of DNA that can replicate and spread through the host genome. They readily move from one site to another either within or between the DNAs, of bacteria, plasmid or bacteriophage.

Bacteria are haploid organisms, their single chromosome is present in the cytoplasm. That is not covered by nuclear membrane.

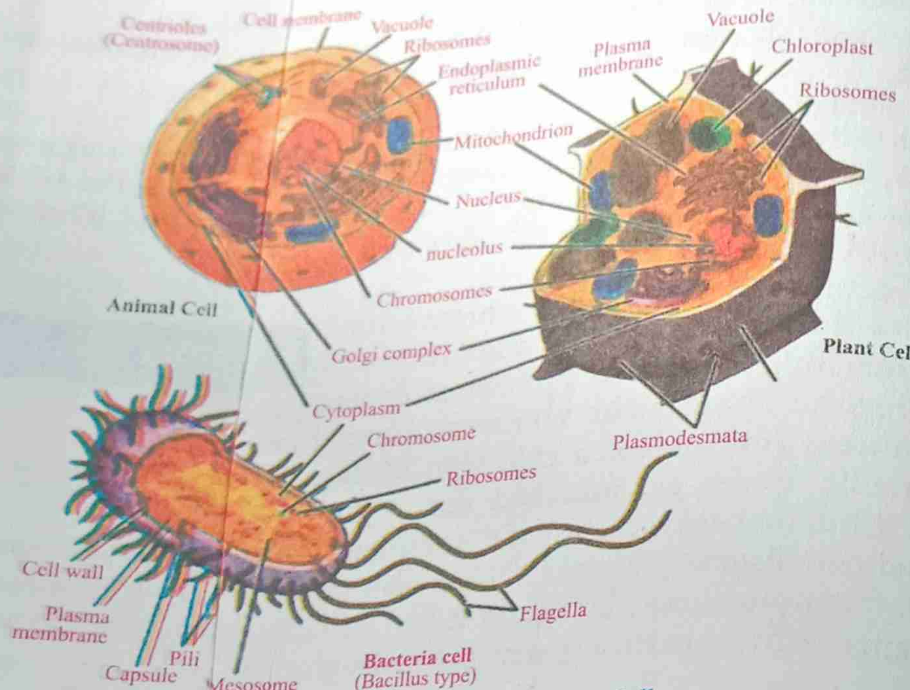


Fig. 1.20 Bacterial, Animal and Plant Cells

Table 1.4 Comparison between prokaryotic and eukaryotic cell

Prokaryotic cell (pro: before, karyon: nucleus)	**Eukaryctic Cell** (eu: true, karyon: nucleus)
• These cells have no prominent nucleus i.e., nuclear material is not bounded by nuclear membrane and nucleolus is also absent.	• These cells have distinct nucleus i.e., nuclear material is enclosed by nuclear membrane and nucleolus is also present.
• Found only in bacteria and cyanobacteria.	• Found in protists, fungi, plants and animals.
• Most membranous organelles are absent and double membrane organelles are not present.	• Most membranous organelles are present which are either covered by single or double lipo- proteinaceous membrane
• Mesosomes are present	• Mesosomes are absent
• 70s Ribosomes.	• 80s Ribosomes
• Single circular chromosome which is composed of only DNA	• 2 or more linear chromosomes are present which are mostly composed of DNA, Protein and little RNA.
• Cell wall contains Polysaccharide with amino acid (peptidoglycan)	• Cell wall is present either composed of cellulose (plants, algae) or chitin (fungi) and absent in animal cells
• Cell divides by binary fission i.e., no mitosis or meiosis.	• Cells divide by mitosis while germ line cells divide by meiosis.

Activity

Improve your knowledge by searching wikipedia and internet sources and make a list of different techniques used in study of structure of cell. Name the cell organelles that contain DNA. Trace the relationship between ribosome, endoplasmic reticulum, Golgi bodies and lysosomes.

Summary of Structures and functions of cellular components

Component	Structure / Description	Function
Centriole	Located within microtubule organizing center. Contains nine triplet microtubules.	Produces basal body of cilia and flagella; help in mitotic spindle formation.
Chloroplast	It possesses chlorophyll in Thylakoids and is involved in photosynthesis.	Traps, transforms, and uses light energy to convert carbon dioxide and water into glucose and oxygen.
Chromosome	Made up of nucleic acid (DNA) and protein and some RNA.	Controls cellular activities and carries genes.
Cilia, flagella	Both are thread like structures.	Cilia and flagella move small particles through fixed cells and their main role is chemotaxis.
Cytoplasm	Semi fluid enclosed within plasma membrane contains fluid cytosole; organelles and other structures.	Dissolves substances and contain suspended organelles and vesicles.
Cytoskeleton	Interconnecting microfilaments and microtubules; flexible cellular framework.	Help in cell movement; provide support; site for binding of specific enzymes.
Endoplasmic reticulum ER	Extensive membrane system extending throughout the cytoplasm from the plasma membrane to the nuclear envelope.	Storage and internal transport; rough ER is a site for attachment of ribosomes; smooth ER makes lipids and detoxification.
Golgi Apparatus	Stacks of disk and tubular shaped cisternae.	Secretion and packaging cellular substances.
Lysosome	Membrane bound sac like.	Digests polymer into monomer i.e. digestion.

Component	Structure / Description	Function
Microfilament	Rod like structure containing protein actin.	Gives structural support and assists in cell movement.
Microtubule	Hollow, cylindrical structure.	Help in movement of cilia flagella, and chromosomes; transport system.
Microtubule organizing center	Cloud of cytoplasmic material that contains centrioles	Dense site in the cytoplasm that gives rise to large numbers of microtubules with different functions in the cytoskeleton
Mitochondrion	Organelle with double, folded membranes, contains DNA, enzymes and coenzyme.	Convert energy into a form the cell can use (power house).
Nucleolus	Rounded mass within nucleus; contains RNA and protein.	Preassembly point for ribosomal subunits.
Nucleus	Spherical structure surrounded by a nuclear envelope; contains nucleolus, DNA and nucleoplasm.	Contains DNA that control cell's genetic program and metabolic activities.
Plasma membrane	The outer bilayer boundary of the cell; composed of protein, cholesterol, and phospholipids.	Protection; regulation of material movement; cell-to-cell recognition and gives shape.
Ribosome	Contains rRNA and protein; some are free, and some are attached to ER.	Site of protein synthesis.
Vacuole	Single membrane-bounded, sac in the cytoplasm.	Storage site of food and other compounds; also pumps water out of a cell (contractile vacuole while in plant non-contractile)
Vesicle	Small, membrane-bounded sac; contains enzymes or secretory products.	Site of intracellular digestion, storage, or transport.

EXERCISE

Section I: Objective Questions

Multiple Choice Questions

A. **Select the correct answer.**

1. Who observed nucleus in the cells of orchids under the microscope?
   (a) A.F.A. King (b) Robert Brown
   (c) Galileo (d) Henri Dutrochet
2. Robert Brown observed nucleus in 1831 in the cells of
   (a) Pea (b) Monkey
   (c) Orchids (d) Euglena
3. What is called the basic structural as well as functional unit of all living organisms?
   (a) Cell (b) Nucleus
   (c) Gland (d) Tissue
4. All cells arise from
   (a) Dead matter (b) Plants
   (c) Saprophytes (d) Pre-existing cells.
5. The function of an organism is the result of sum of activities and interaction of the
   (a) Neurons (b) Tissues
   (c) Muscles (d) Cells
6. Which type of cells can contract and relax?
   (a) Muscle Cells (b) Excretory Cells
   (c) Nervous Cells (d) Phloem Cells
7. Which type of cells transmit nerve impulses?
   (a) Muscle Cells (b) Nerve Cells
   (c) Nephron Cells (d) Xylem Cells
8. Which type of cells secrete hormones?
   (a) Tissues Cells (b) Muscles Cells
   (c) Respiratory Cells (d) Gland cells
9. Which of the following blood cells carry oxygen?
   (a) W.B.Cs (b) Platelets
   (c) R.B.Cs (d) Thrombocytes
10. In plants, which type of cells carry out photosynthesis?
    (a) Chlorenchymatous (b) Sclerenchymatous
    (c) Meristem cell (d) Collenchymatous

11. The modern technology enables us to isolate various components of cells including its organelles by a process known as

(a) Isolation
(b) Fractionation
(c) Centrifugation
(d) Fermentation

12. It is the outermost layer of the animal cell. It is thin, delicate, elastic and capable of limited self repair". This statement is true for which cell structure?

(a) Cell Wall
(b) Cell Membrane
(c) Nuclear Membrane
(d) Ribosome

13. Cell membrane allows some of the soluble particles to pass through but prevents others. This property is most appropriate to membrane which is

(a) Permeable
(b) Impermeable
(c) Selectively Permeable
(d) Semipermeable

14. In many animal cells the cell membrane helps to take in materials by infolding in the form of vacuoles. This type of intake is termed as

(a) Endocytosis
(b) Phagocytosis
(c) Pinocytosis
(d) Glycolysis

15. Which is called the ingestion of solid material through the cell membrane?

(a) Endocytosis
(b) Phagocytosis
(c) Pinocytosis
(d) Glycolysis

B. Fill the blank spaces with suitable words.

1. Borax carmine is an example of .... staining.
2. The term tissue culture was used by American pathologist ....
3. The discovery of cell was directly related with the invention of the ....
4. The cell is the unit of function and structure of ....
5. Magnification power of microscope depends on ....
6. Group of ribosomes attached to mRNA is known as ....
7. Ribosomes are synthesized in ....
8. The factory for protein synthesis is the ....
9. Secretory and packaging organelle of cell is called ....
10. Glyoxisomes are the most abundantly found in ....
11. Microfilaments are composed of contractile ....
12. Mitochondrial infoldings are called ....
13. The inner surface of cristae in mitochondrial matrix has small knob like structure known as ....
14. Grana is the site for ....
15. Chromatids are held together at ....